REGIONAL GIS DATABASES IN SUPPORT OF CTBT MONITORING

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ABSTRACT

To fully exploit the effectiveness of different monitoring technologies, a large knowledge base is being built. A database encompassing basic geologic information such as bedrock geology, faults, and geophysical information needs to be collected and combined for many different regions. The specific regions that our study focuses on are the United States and the Middle East and North Africa. The interest in the United States is to develop a database that can be used in the CTBT to guide on-site inspections. For the Middle East and North Africa, improvement in monitoring to advance CTBT compliance and verification is desired. The objective is to collect, evaluate, and analyze geological, geophysical, and seismic data in a Geographic Information System database; and deliver files containing such data to DTRA.

Currently, we have developed complete digital depth-to-Moho and depth-to-basement maps for the Middle East and North Africa region and evaluated them using 3-D gravity modeling. We have also made our first version of gridded depth-to-Moho and depth-to-basement maps of the United States. These data sets are now being evaluated and checked for accuracy and completeness. We have compiled an initial Lg attenuation map for the U.S. A first-order seismic velocity database consisting of Pn and Pg velocities in the U.S. is also being compiled along with geology and fault maps. Different types of databases are already collected and evaluated for the Middle East, North Africa, and the USA.

An important component of our research is to develop complete metadata for all collected data sets. As we develop and finalize a data set, we are also developing a complete FGDC standard metadata files to accompany the digital data sets. These metadata files will be delivered along with the data sets to the R & D testbed at the Center for Monitoring Research. Most of the Cornell databases can be accessed via our web site: http://atlas.geo.cornell.edu/

KEY WORDS: GIS, databases, Middle East, North Africa, USA

OBJECTIVE

Our main objective is to facilitate and enhance the capability of the U.S. National Data Center and the International Monitoring System to accurately locate, calibrate, and evaluate seismic events in the Middle East, North Africa, and the United States, by developing an interactive, diversified geophysical, geological, and geographical digital databases to assist in compliance with and verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). We are also developing and improving the design of menu-driven, easy to use, custom-made tools as well as metadata for all developed data sets. The metadata will provide the necessary information about the quality, resolution, accuracy, and techniques that were used in collecting the original data. Another objective is to deliver results of the original research on crustal and upper mantle structures of the Middle East and North Africa, and the character of regional seismic wave propagation for the purpose of obtaining a better understanding of high-frequency wave propagation in this region.

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RESEARCH ACCOMPLISHED

Our efforts in global and regional GIS database development in support of CTBT monitoring have been going on successfully. We have added new data sets to our digital library and revised our data access tools in the past year. We have updated a number of databases.

We have finalized the depth-to-basement map for the U.S. and nearby regions (Figure 1). This basement map is a compilation of 13 different depth-to-basement data sets. The maps that comprise these data set were collected and digitized at Cornell University and were later compiled by the ArcInfo command topogrid into one 5-km-resolution grid. A sediment depth map of the United States was clipped and used to 'fill in' this hole. The University of California at San Diego data were correlated for ocean depth using the Smith and Sandwell (1997) values. A polygon coverage was created of the area missing data and was used to clip the depth-to-sediment grid (10-km resolution). The clipped grid was then converted to a point coverage. The depth-to-sediment data were used in the absence of any other useful depth-to-basement data for these regions and was used in the gridding process to help constrain the data in these regions. When using this grid in these regions, users should be aware that these data are not depth-to-metamorphic basement and use it accordingly.

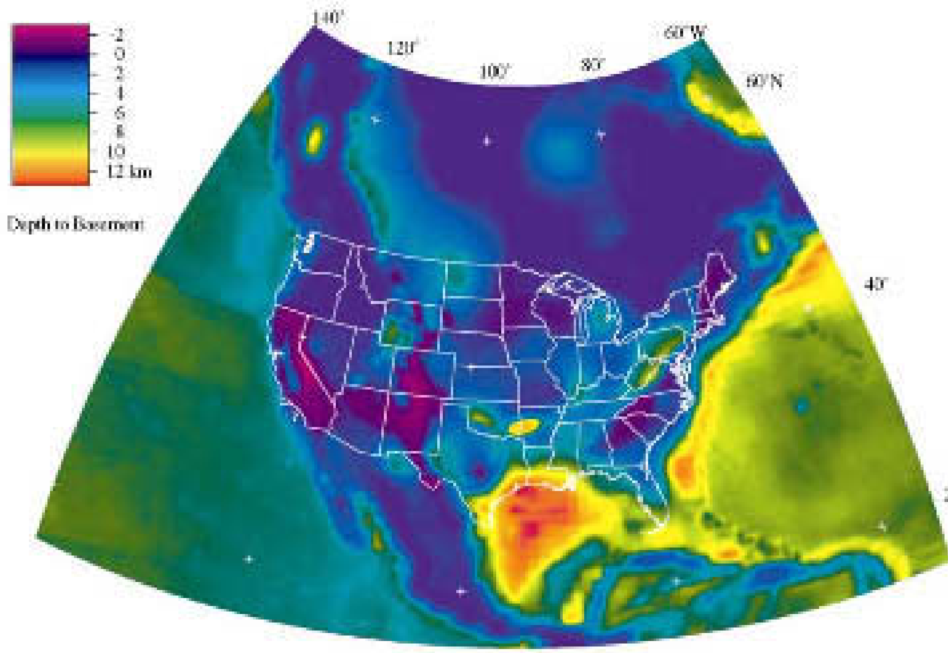

Figure 1. Depth to metamorphic basement for North America.

We have finalized a detailed Moho map for all of North America (Figure 2). An extensive literature search for estimates of Moho depth in the continental United States revealed 58 published papers. The authors had employed different methods to determine depth: seismic reflection and refraction, receiver functions, ray tracing, amplitude modulation, gravity, travel-time residuals, surface waves, refraction tomography, and PmP arrival times. Several methods were used to put the data into digital form. From papers that listed depths at point locations, the data were built as an ArcInfo point coverage. From papers that contained a depth profile, a point coverage was made of data from several locations. From papers that contained a contour map of Moho depth, the contours were scanned, digitized (using R2V software), built as an ArcInfo line coverage, and then converted to a point coverage using the ARCPOINT command in ArcInfo. In one case, we received from the authors (Das and Nolet, 1998) an ASCII file of the published grid and put it into ArcInfo grid format. To correct for elevation, we first created a long-wavelength topography grid by traversing a 3X3 low-pass filter

800 times over the United States Geological Survey gtopo30 grid. This smoothed topography grid was then subtracted from the Das and Nolet (1998) grid. We resampled it to 500 m cell size and converted it to a point coverage with the ArcInfo command, GRIDPOINT.

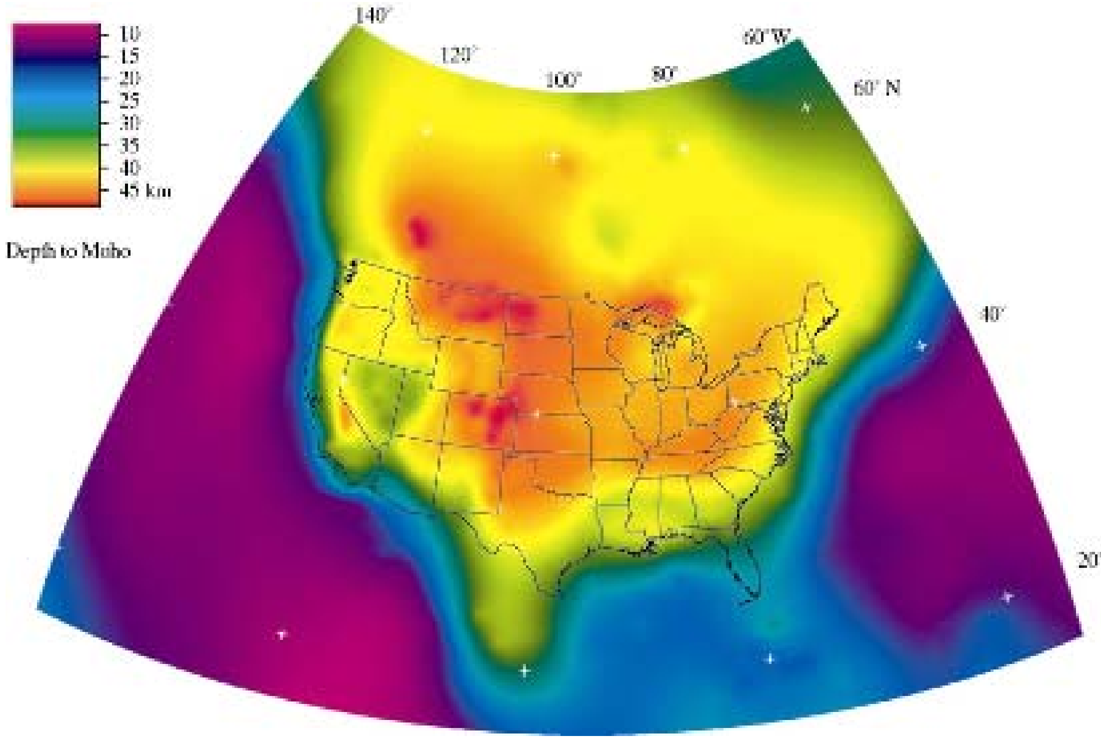

Figure 2. A depth to Moho map for North America. This map was created using a wide variety of techniques to image crustal thickness.

In the published papers, Moho depth was variously stated as depth from the surface and depth from sea level; we have chosen to use sea level as our datum. Where the published values were defined as depth from sea level, or where values were depth from surface but the surface elevation was within our error limits, no modification was necessary. Where correction was necessary, one of four different methods was employed: in coverages with few points, the elevation at each location was subtracted. In contour coverages for a region with a narrow range of elevations, the mean elevation was subtracted from all values. Where the contours covered a broad range of elevation, we gridded the contours, subtracted the smoothed USGS topography grid, and then re-contoured the resulting grid. The offshore coverage had many points; these were corrected outside of ArcInfo using global bathymetry data. Data from Soller et al. (1982) were used only where there were no other data. To do this, a polygon was drawn by eye around all the non-Soller data, and then Soller points (already depth-corrected) inside the polygon were erased. The data were smoothed to prevent high-frequency vertical relief due to mutually inconsistent datasets; we smoothed differences of less than 3 km.

In our efforts to compile a comprehensive Moho depth data set, we not only record the point and the corresponding depth value, but also record all other relevant information such as the author names, publication source, the method used in obtaining the Moho point. This is extremely useful for researchers as they will always want to know about the details, resolution, and accuracy of the final gridded Moho map. These original point/contour information will be critical in judging the accuracy of the Moho map of the U.S. Results of this work will be essential to improve event locations and IMS calibration for the USA.

In the Middle East and North Africa region we have improved our data coverage extent of the Moho and basement maps by collecting more data sets. We have now a complete crustal model for the entire Middle East and North Africa. This model is now being evaluated with independent data sources such as Bouguer gravity

data and three-dimensional gravity modeling to determine which regions have reliable depth-to-Moho values, and which regions might need additional revisions.

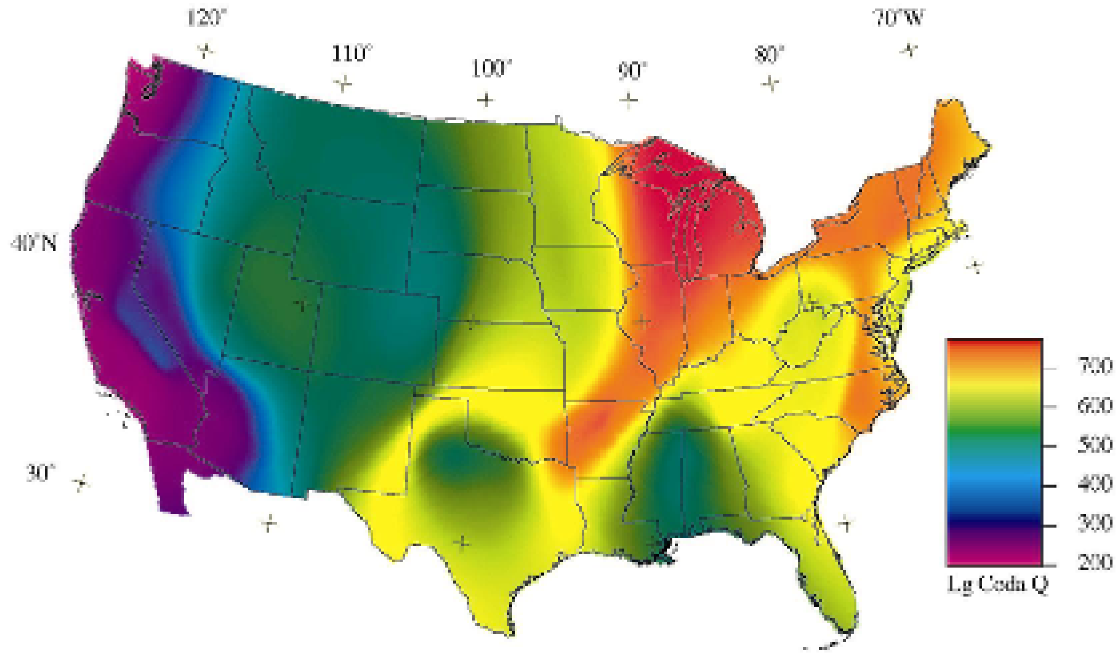

Figure 3. Lg coda Q map for the conterminous United States which were created using measurements taken from Baqer and Mitchell (1998).

In order to create a Lg coda Q map for the entire United States (Figure 3) we used 218 Lg coda Q measurements of Baqer and Mitchell (1998). For each pair, an arc connecting the event and station was created and given the 1 Hz Q value. Points were drawn along each arc and assigned the same Q value. Then a contour coverage was created, based on the point values. Finally, the contours were used to create a grid in Arc Info. The resulting map is an estimate of the spatial variation in Lg coda Q for the conterminous United States.

We are continuing to improve upon the Pn tomographic models for the Middle East. Our current model using approximately 3.5 years of phase data from Syria National Network, we have identified a very prominent low velocity zone that extends along most of the Dead Sea Fault System (DSFS) (Figure 4) that was suggested in early work (Hearn and Ni, 1994). The origin of this low-velocity zone is unclear as the most recent studies of the DSFS have concluded that it is not a simple rift. We are significantly expanding the available phase data in the region by picking phases from a number of temporary networks in the region including data from the Eastern Turkey Seismic Experiment.

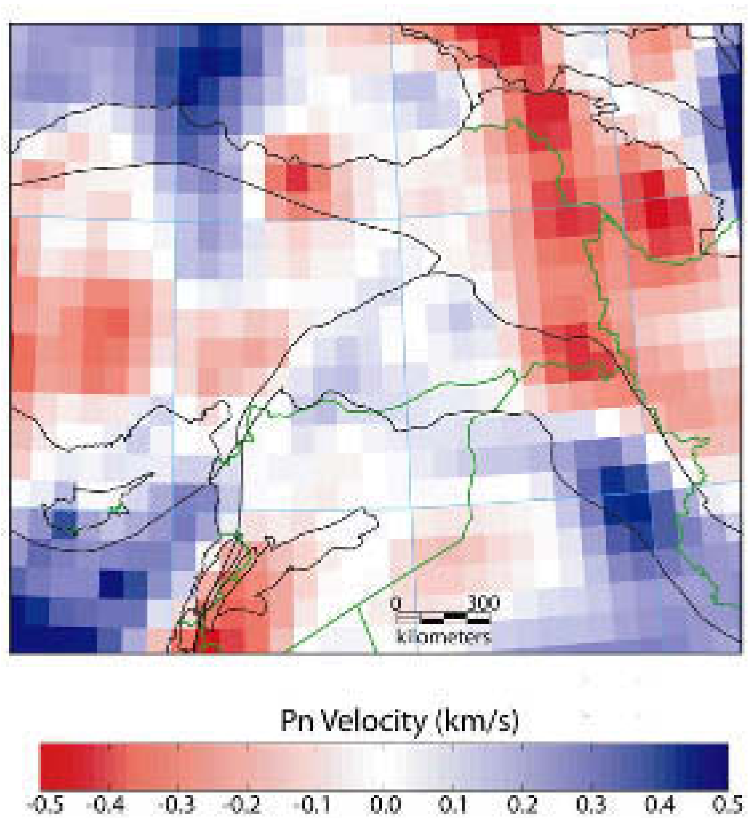

Figure 4. Pn tomographic model for the Northern Middle East.

CONCLUSIONS AND RECOMMENDATIONS

We have been collecting and organizing available seismological, geophysical, and geological data sets for the Middle East, North Africa and the United States into a comprehensive Geographic Information System (GIS). In addition to the GIS databases and tools, we have been developing a special World Wide Web (WWW) site for our databases. All the data sets in our GIS system are documented with a standard metadata format in order to explain the source and nature of the data, their resolution, and their accuracy. The developed system and its efficiency in using and analyzing information will help CTBT researchers and decision makers to fuse and integrate the results of the four established monitoring technologies (seismic, hydroacoustic, infrasound, and radionuclide) to reach a conclusion in a very short time. The system also significantly contributes to the better location and calibration of suspect events for any given region. This system will also help in On Site Inspection efforts.

We recommend that ongoing efforts to develop databases be expanded to include higher resolution data sets not only for the regions of the Middle East, North Africa, and the U.S., but also to most regions on Earth. Such developed information system and data sets will help to achieve better event locations with the required accuracy as stated in the CTBT.

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